U.S. DEPARTMENT OF COMMERCE
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PB-276 824

Soda Lake
Sublette County
Wyoming

National Eutrophication Survey, Corvallis, Oreg.

Prepared for

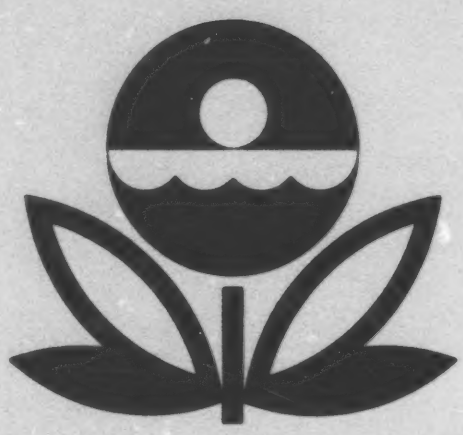
Corvallis Enviromental Research Lab., Oreg.

Sep 77

PB 276 824

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES



REPORT
ON
SODA LAKE
SUBLETTE COUNTY
WYOMING
EPA REGION VIII
WORKING PAPER No. 891

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON
and
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

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REPORT
ON
SODA LAKE
SUBLETTE COUNTY
WYOMING
EPA REGION VIII
WORKING PAPER No. 891

WITH THE COOPERATION OF THE
WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
AND THE
WYOMING NATIONAL GUARD
SEPTEMBER, 1977

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO. PB276824
4. TITLE AND SUBTITLE Report on Soda Lake, Sublette County, Wyoming		5. REPORT DATE Prepared September 1977 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper # 891
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1975 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		48G

18. DISTRIBUTION STATEMENT Release unlimited	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES 24
	20. SECURITY CLASS *(This page)*	22. PRICE Aϕ2-Aϕ1

EPA Form 2220-1 (9-73)

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Wyoming Department of Environmental Quality for professional involvement, to the Wyoming National Guard for conducting the tributary sampling phase of the Survey, and to those Wyoming wastewater treatment plant operators who voluntarily provided effluent samples.

The staff of the Water Quality Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

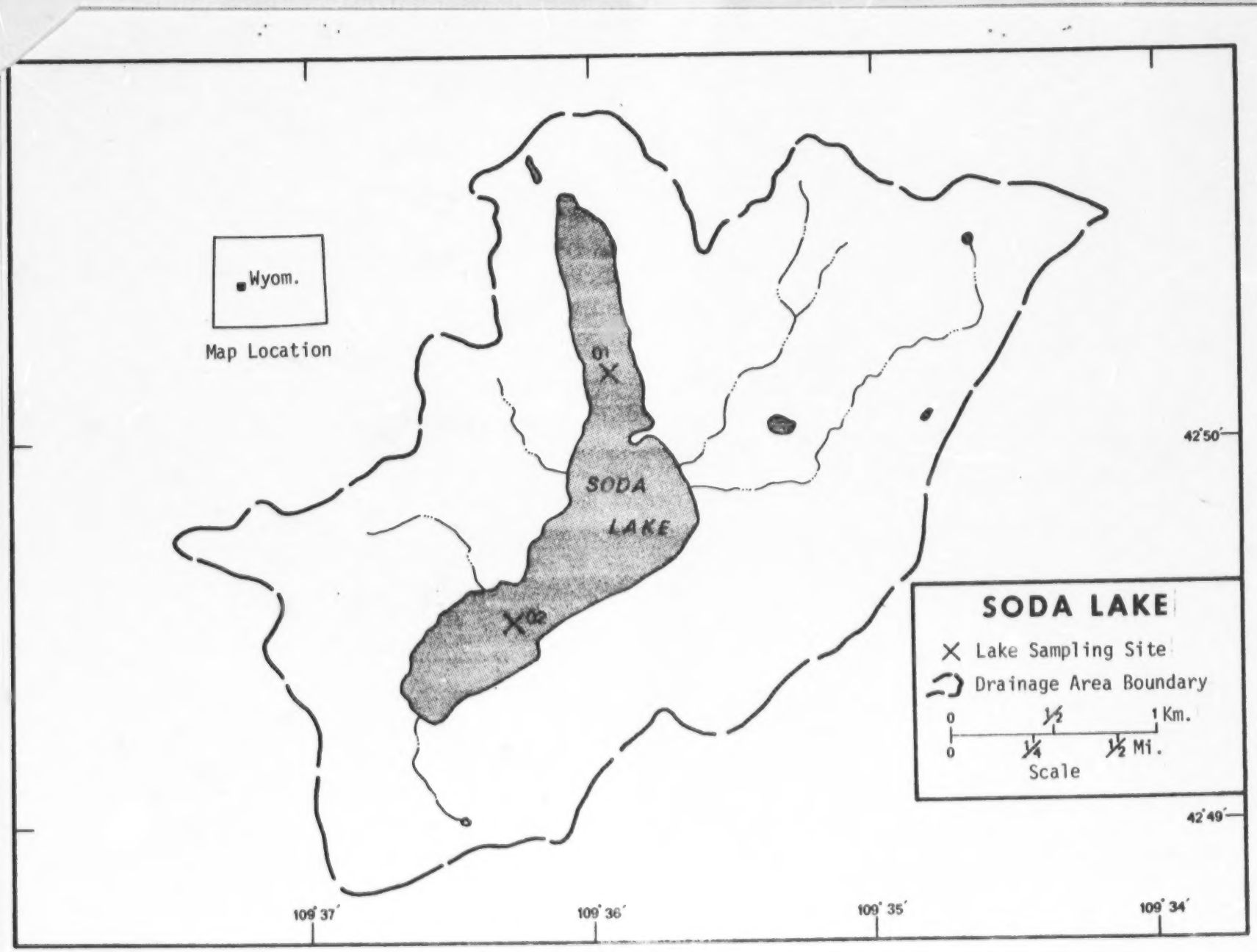
Brigadier General James L. Spence, The Adjutant General of Wyoming, and Project Officer Colonel Donald L. Boyer, who directed the volunteer efforts of the Wyoming National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of Wyoming

NAME	COUNTY
Big Sandy	Sublette, Sweetwater
Boulder	Sublette
Boysen	Fremont
De Smet	Johnson
Flaming Gorge	Sweetwater, WY; Daggett, UT
Fremont	Sublette
Glendo	Converse, Platte
Keyhole	Crook
Ocean	Fremont
Seminoe	Carbon
Soda	Sublette
Viva Naughton	Lincoln
Woodruff Narrows	Uinta
Yellowtail	Bighorn, WY; Bighorn, Carbon, MT


Wyom.
Map Location
01
SODA
LAKE
02
42°50'
42°49'
109° 37'
109° 36'
109° 35'
109° 34'
SODA LAKE
Lake Sampling Site
Drainage Area Boundary
0
½
1 Km.
0
¼
½ Mi.
Scale

SODA LAKE

STORET NO. 5011

I. INTRODUCTION

Soda Lake was included in the National Eutrophication Survey as a water body of interest to the Wyoming Department of Environmental Quality. Tributaries and nutrient sources were not sampled, and this report relates only to the lake sampling data.

II. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Soda Lake is eutrophic. It ranked ninth in overall trophic quality when the 14 Wyoming lakes and reservoirs sampled in 1975 were compared using a combination of six parameters*. Ten of the water bodies had less median total phosphorus, seven had less and two had the same median orthophosphorus, none had less and four had the same median inorganic nitrogen, five had less mean chlorophyll a, and four had greater mean Secchi disc transparency. Depletion of hypolimnetic dissolved oxygen occurred at both sampling stations in August and at station 1 in October.

B. Rate-Limiting Nutrient:

The algal assay results indicate the primary productivity of Soda Lake was limited by nitrogen at the time the sample was collected (10/20/75). The lake data indicate nitrogen limitation at both sampling times.

---

* See Appendix A.

III. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 1.11 kilometers^2.
2. Mean depth: Unknown.
3. Maximum depth: 67.1 meters.
4. Volume: Unknown.

B. Precipitation*:

1. Year of sampling: 25.7 centimeters.
2. Mean annual: 28.5 centimeters.

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† Table of metric conversions--Appendix B.
†† Prior, 1974.
* See Working Paper No. 175, "...Survey Methods, 1973-1976".

IV. WATER QUALITY SUMMARY

Soda Lake was sampled two times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the October visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 53.3 meters at station 1 and 15.8 meters at station 2.

The sampling results are presented in full in Appendix C and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR SODA LAKE
STORET CODE 5611

PARAMETER	1ST SAMPLING (8/28/75) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (10/20/75) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (**/**/**) 0 SITES RANGE	MEAN	MEDIAN
TEMP (C)	3.4 - 17.2	10.3	11.5	6.5 - 12.0	10.0	11.9	******	----------	
DISS OXY (MG/L)	0.0 - 7.6	3.9	6.0	0.0 - 8.4	4.6	7.6	******	----------	
CNDCTVY (MCROMO)	2230. - 3216.	2720.	2441.	2269. - 3709.	2636.	2503.	******	----------	
PH (STAND UNITS)	9.4 - 9.5	9.5	9.5	9.5 - 9.6	9.5	9.5	******	----------	
TOT ALK (MG/L)	1920. - 2620.	2214.	2320.	1540. - 2260.	1981.	2020.	******	----------	
TOT P (MG/L)	0.037 - 0.308	0.099	0.062	0.049 - 0.317	0.118	0.064	******	----------	
ORTHO P (MG/L)	0.003 - 0.259	0.062	0.020	0.003 - 0.290	0.072	0.009	******	----------	
NO2+NO3 (MG/L)	0.020 - 0.020	0.020	0.020	0.020 - 0.040	0.022	0.020	******	----------	
AMMONIA (MG/L)	0.020 - 0.460	0.091	0.020	0.020 - 0.500	0.098	0.020	******	----------	
KJEL N (MG/L)	1.800 - 4.300	2.562	2.600	2.100 - 4.400	2.755	2.400	******	----------	
INORG N (MG/L)	0.040 - 0.480	0.111	0.040	0.040 - 0.540	0.120	0.040	******	----------	
TOTAL N (MG/L)	1.820 - 4.320	2.582	2.620	2.120 - 4.420	2.776	2.420	******	----------	
CHLRPYL A (UG/L)	2.6 - 3.7	3.1	3.1	7.8 - 8.2	8.0	8.0	******	----------	
SECCHI (METERS)	3.2 - 3.4	3.3	3.3	2.4 - 2.4	2.4	2.4	******	----------	

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
08/28/75	1. Cyanophytan coccoid colonies	221
	2. *Elakatothrix sp.*	85
	3. *Aphanizomenon sp.*	17
	Total	323
10/20/75	1. *Campylodiscus sp.*	trace
	2. *Pediastrum sp.*	trace
	3. *Navicula sp.*	trace

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
08/28/75	1	2.6
	2	3.7
10/20/75	1	8.2
	2	7.8

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.035	0.215	6.8
0.050 P	0.085	0.215	7.1
0.050 P + 1.0 N	0.085	1.215	31.9
1.0 N	0.035	1.215	17.7

2. Discussion -

The control yield of the assay alga, *Selenastrum capricornutum*, indicates that the potential primary productivity of Soda Lake was high at the time the assay sample was collected (10/20/75). Also, the increase in yield when only nitrogen was added indicates nitrogen limitation at

that time.

The lake data indicate nitrogen limitation both sampling times (the mean inorganic nitrogen to orthophosphorus ratios were less than two to one both times).

V. LITERATURE REVIEWED

Prior, Roy E., 1974. Personal communication (lake morphometry). WY Dept. of Env. Qual., Cheyenne.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
5601	BIG SANDY RESERVOIR	0.087	0.060	487.667	4.383	8.800	0.020
5602	BOULDER LAKE	0.008	0.040	361.800	2.483	8.400	0.002
5603	BOYSEN RESERVOIR	0.037	0.140	465.923	6.264	14.400	0.014
5604	LAKE DE SMET	0.033	0.040	409.000	11.167	9.400	0.006
5605	FLAMING GORGE RESERVOIR	0.014	0.605	366.461	5.611	12.200	0.003
5606	FREMONT LAKE	0.006	0.040	-22.000	3.783	7.400	0.002
5607	GLENDO RESERVOIR	0.045	0.315	459.182	8.473	12.600	0.014
5608	KEY HOLE RESERVOIR	0.028	0.050	454.583	7.792	14.000	0.004
5609	OCEAN LAKE	0.043	0.040	478.333	7.500	8.600	0.004
5610	SEMINOLE RESERVOIR	0.030	0.130	447.000	2.536	11.000	0.007
5611	SODA LAKE	0.063	0.040	387.500	5.575	15.000	0.014
5612	VIVA NAUGHTON RESERVOIR	0.065	0.120	430.000	25.067	13.200	0.024
5613	WOODRUFF NARROWS RESERVO	0.069	0.105	470.000	12.950	13.200	0.019
5614	YELLOWTAIL RESERVOIR	0.026	0.310	364.500	5.410	10.000	0.017

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLORA	15- MIN DO	MEDIAN DISS ORTHO P	INDEX NO
5601	BIG SANDY RESERVOIR	0 (0)	54 (7)	0 (0)	77 (10)	77 (10)	8 (1)	216
5602	BOULDER LAKE	92 (12)	92 (11)	92 (12)	100 (13)	92 (12)	92 (12)	560
5603	BOYSEN RESERVOIR	46 (6)	23 (3)	23 (3)	46 (6)	8 (1)	42 (5)	188
5604	LAKE DE SMET	54 (7)	73 (9)	62 (8)	15 (2)	69 (9)	62 (8)	335
5605	FLAMING GORGE RESERVOIR	85 (11)	0 (0)	77 (10)	54 (7)	46 (6)	85 (11)	347
5606	FREMONT LAKE	100 (13)	73 (9)	100 (13)	85 (11)	100 (13)	100 (13)	558
5607	GLENDO RESERVOIR	31 (4)	8 (1)	31 (4)	23 (3)	38 (5)	42 (5)	173
5608	KEY HOLE RESERVOIR	69 (9)	62 (8)	38 (5)	31 (4)	15 (2)	69 (9)	284
5609	OCEAN LAKE	38 (5)	92 (11)	8 (1)	38 (5)	85 (11)	77 (10)	338
5610	SEMINOLE RESERVOIR	62 (8)	31 (4)	46 (6)	92 (12)	54 (7)	54 (7)	339
5611	SODA LAKE	23 (3)	92 (11)	69 (9)	62 (8)	0 (0)	31 (4)	277
5612	VIVA NAUGHTON RESERVOIR	15 (2)	38 (5)	54 (7)	0 (0)	27 (3)	0 (0)	134
5613	WOODRUFF NARROWS RESERVO	8 (1)	46 (6)	15 (2)	8 (1)	27 (3)	15 (2)	119
5614	YELLOWTAIL RESERVOIR	77 (10)	15 (2)	85 (11)	69 (9)	62 (8)	23 (3)	331

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	5602	BOULDER LAKE	560
2	5606	FREMONT LAKE	558
3	5605	FLAMING GORGE RESERVOIR	347
4	5610	SEMINOLE RESERVOIR	339
5	5609	OCEAN LAKE	338
6	5604	LAKE DE SMET	335
7	5614	YELLOWTAIL RESERVOIR	331
8	5608	KEY HOLE RESERVOIR	284
9	5611	SODA LAKE	277
10	5601	BIG SANDY RESERVOIR	216
11	5603	BOYSEN RESERVOIR	188
12	5607	GLENDO RESERVOIR	173
13	5612	VIVA NAUGHTON RESERVOIR	134
14	5613	WOODRUFF NARROWS RESERVO	119

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/09/29

561102
42 49 33.0 109 36 17.0 3
SODA LAKE
56035 WYOMING

11EPALES 2111202
0056 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/08/28	11	25 0000	17.2	7.0	126	3216	9.40	1940	0.040	2.700	0.020K	0.020
	11	25 0005	17.2	6.8		3210	9.50	1980	0.020	2.600	0.020K	0.006
	11	25 0025	11.5	6.0		2230	9.50	2080	0.020	2.700	0.020K	0.005
	11	25 0035	5.9	1.6		2441	9.45	2620	0.210	2.800	0.020K	0.050
	11	25 0052	4.5	0.0		2338	9.40	2320	0.460	2.800	0.020K	0.099
75/10/20	09	15 0000	12.0	8.4	96	2707	9.60	1810	0.030	2.100	0.020K	0.009
	09	15 0005	12.0	8.2		2503	9.60	1840	0.020	2.200	0.020K	0.005
	09	15 0020	11.9	8.1		2591	9.60	2160	0.020	2.400	0.020K	0.004
	09	15 0040	9.7	1.4		2335	9.50	2020	0.180	3.000	0.020K	0.045

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/08/28	11	25 0000	0.037	3.7	
	11	25 0005	0.040		
	11	25 0025	0.062		
	11	25 0035	0.101		
	11	25 0052	0.127		
75/10/20	09	15 0000	0.053	7.8	
	09	15 0005	0.053		
	09	15 0020	0.064		
	09	15 0040	0.167		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/29

561101
42 50 12.0 109 35 56.0 3
SODA LAKE
56035 WYOMING

11EPALES 2111202
0999 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/08/28	10 50	0000	17.1	7.2	132	3206	9.50	1920	0.020	1.800	0.020	0.003
	10 50	0005	17.1	7.6		3207	9.50	2320	0.020	2.000	0.020K	0.004
	10 50	0011	16.8	7.4		3187	9.50	2400	0.020	2.100	0.020K	0.004
	10 50	0025	11.8	6.8		2884	9.50	2340	0.020	2.200	0.020K	0.004
	10 50	0050	5.1	0.6		2375	9.50	2380	0.290	2.300	0.020K	0.067
	10 50	0090	3.4	0.0		2325	9.50	2000	0.020K	2.200	0.020K	0.112
	10 50	0130	3.4	0.0		2354	9.45	2020	0.020K	2.800	0.020K	0.179
	10 50	0170	3.5	0.0		2391	9.40	2460	0.020K	4.300	0.020K	0.259
75/10/20	09 45	0000	12.0	8.4	96	3709	9.55	1760	0.030	2.300	0.020K	0.005
	09 45	0005	12.0	8.3			9.55	2100	0.020	2.300	0.020K	0.004
	09 45	0020	11.9	7.6			9.55	1860	0.020	2.200	0.020K	0.003
	09 45	0045	8.4	0.0			9.50	2260	0.220	2.600	0.020K	0.065
	09 45	0085	6.6	0.0			9.50	1540	0.500	3.000	0.040	0.102
	09 45	0130	6.5	0.0		2269	9.50	2240	0.020K	3.800	0.020K	0.265
	09 45	0175	6.5	0.0		2340	9.50	2200	0.020K	4.400	0.020K	0.290

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/08/28	10 50	0000	0.039	2.6	
	10 50	0005	0.040		
	10 50	0011	0.040		
	10 50	0025	0.044		
	10 50	0050	0.096		
	10 50	0090	0.136		
	10 50	0130	0.214		
	10 50	0170	0.308		
75/10/20	09 45	0000	0.053	8.2	
	09 45	0005	0.049		
	09 45	0020	0.057		
	09 45	0045	0.112		
	09 45	0085	0.151		
	09 45	0130	0.218		
	09 45	0175	0.317		

K VALUE KNOWN TO BE
LESS THAN INDICATED